FW BELL INC.

ELECTRONIC DESIGN • DEVELOPMENT • MANUFACTURING

OPERATING MANUAL FOR

DIGITAL CURRENT METER

MODEL 1776

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CONTROLLED DOCUMENT

MAR 2 2 1995

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SIMPLIFIED OPERATING INSTRUCTIONS

1. Connect the 1776 Digital Current Meter to the appropriate power source. Connect the probe to the 1776. Turn the instrument on. A warm-up time of ½-hour is recommended.

2. Depress the CAL button and adjust the calibration potentiometer to obtain a 1000 reading. The instrument is now calibrated. Release the CAL button.

3. With the probe connected, but not clamped around an unknown current, adjust the COARSE and FINE zero controls to obtain a zero meter reading. The instrument is now ready to make measurements.

4. To make ac measurements, depress the ac/dc button. For dc measurements, the button should be in the released position. To make the measurement, simply clamp the probe around the unknown current and read the meter. Remember that the dc mode measures the dc component of the unknown current. The ac mode measures the ac component of the unknown current. The meter is average responding, calibrated to indicate the rms value of a pure sine wave function.

5. The PEAK reading button is used to read and hold the peak current present during a particular time span. Depress the PEAK button. The meter will display the highest positive peak current which flows through the conductor during the time the button is depressed. If there is more than one peak, the instrument will display the maximum absolute peak current. The reset clears the hold circuitry and prepares it for reading a new peak.

Please read this entire manual for complete instructions.

SPECIFICATIONS

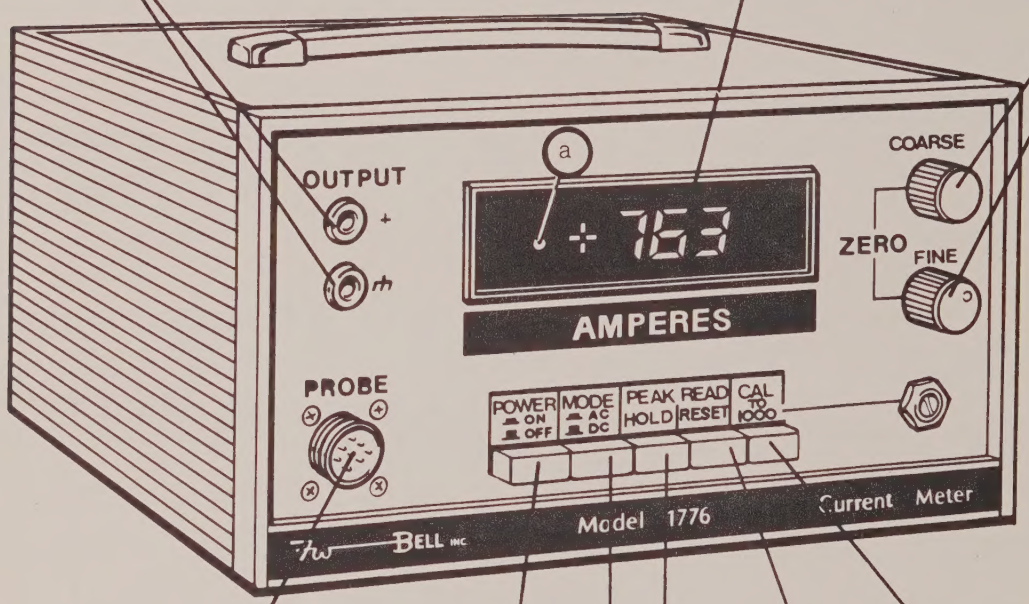
CURRENT RANGES, dc and ac rms	0 to 10.00 A FS with probe P-100; overrange to 19.99 A. 0 to 100.0 A FS with probe P-101; overrange to 199.9 A. 0 to 1000 A FS with probe P-102; no overrange
OVERALL ACCURANCY, INCLUDING PROBES dc and sinusoidal ac to 1000 Hz	normal range: ±1.0% FS at 25°C. overrange: ±2.5% FS at 25°C.
peak reading	±2.0% FS.
FREQUENCY RESPONSE IN ac MODE additional error 1000 Hz to 5000 Hz	10 Hz to 5000 Hz. with P-100 (10 A) probe: +2.0% of reading, typical. With P-101 (100 A) probe: +3.0% of reading, typical. With P-102 (1000 A) probe: +3.0% of reading, typical.
PEAK READING	frequency response: 1000 Hz. fastest readable rise time: 250μs to full scale.
OUTPUT VOLTAGE	in dc mode: ±1.0 V for full scale indication. in ac mode: 1.0 V rms for full scale indicati of sinusoidal current. in peak hold mode: +1.0 V hold for full scale peak hold indication.
READOUT	digital, 3½ digits.
PROBE ISOLATION CAPABILITY	600 V dc or ac peak.
POWER REQUIREMENTS	115/230 V ac, 50/60 Hz and internal re-chargeable Nicad batteries with built-in trickle charge circuitry (voltage selection is made at the factory) 15 W.
SIZE	5½" high, 10" wide, 10" deep (140 mm x 254 mm x 254 mm).
WEIGHT	net 10 lbs. (4.5 kg), shipping 13 lbs. (5.9 k
OPERATING TEMPERATURE RANGE	-10°C to +50°C.
SPECIAL FEATURES	All probes can be calibrated using the internal calibration feature of any 1776. The P-100 (10A) and P-101 (100A) probes have 100% overrange capability with slightly reduced accuracy.

1776 CONTROLS AND SPECIAL FEATURES

OUTPUT
±1 volt for full scale indication on dc, 1 volt rms for full scale indication on ac.

DIGITAL READOUT
This 3½ digit display shows the current measured. Polarity of dc currents is also indicated.

ZERO
Coarse and *fine* zero controls, zero the instrument reading.



(a) BATTERY INDICATOR
This indicator lights when the internal battery charge level drops to a point where accurate measurements are no longer possible. The 1776 should be operated on the line or recharged for later use when this lights.

PROBE CONNECTOR
One of three available probes can be connected here. The instrument automatically ranges to the appropriate probe when it is connected.

CALIBRATE
Depress this button to calibrate the 1776 to a full scale reading of 1000

ON/OFF SWITCH
Depress this button to turn the instrument on.

AC-DC FUNCTION
When depressed, this switch permits ac current measurements. When released, the instrument is in dc mode.

RESET
This button clears the peak reading indication and prepares the instrument for the next peak reading.

PEAK READ
When the HOLD button is depressed, the 1776 will read and hold the highest positive peak current indefinitely until the RESET button is used to clear the instrument.

DESCRIPTION

The Bell model 1776 Digital Current Meter provides a revolution in metrology via its ability to accurately measure ac, dc, (and ac on dc) current with a non-contact clamp-on probe. No longer is it necessary to break the circuit to make a current measurement. This time saving feature is extremely helpful in the troubleshooting, repair, and design fields. Now it's possible to obtain current measurements more easily and safely than voltage measurements with isolation from the bus.

The Bell model 1776 Digital Current Meter introduces virtually no resistance on dc readings and extremely small impedance on ac readings. In this way, measurements can be made with a minimum of disturbance in the measured circuit, a tremendous advantage in making those difficult transient response tests.

The unique circuit design coupled with the digital readout provides a wide dynamic range of measurements with excellent resolution. For example, readings can be made down to 10 milliamperes while the upper end limit is 1000 amps dc or rms ac.* The 1776 is designed for portable operation with internal rechargeable batteries and for 115/230 Vac, 50-60 Hz line operation.

These and other unique capabilities and features make the 1776 Digital Current Meter the most versatile and useful current measuring instrument available. It has been designed to meet your needs.

* A dynamic range of 100,000 to 1.

SECTION III

Installation and Pre-Operation Adjustments

III-1

(a) Power Requirements

The Model 1776 operates from a 115 volt ac or 230 volt ac line at 50 or 60 Hz. Each instrument is pre-adjusted at the factory to the 115 or 230 volt operation levels. Check the rating of your instrument to make sure that the voltages match. Instruments rated at 115 volt operation have no identifying power tag while the 230 volt operation instruments have a tag identifying them as 230 volts. All units accept 50 or 60 Hz power.

Internal rechargeable NICAD batteries provide true portable operation. A built-in trickle charger maintains the NICAD batteries at full charge while the instrument is attached to the ac line and is "on". When attached to the line and "off", the instrument recharges the batteries at a full recharge. For example, after eight hours of portable operation the 1776 should be attached to the ac line in the "off" position for sixteen hours. The instrument draws 15 watts of power.

(b) Pre-Operation:

Attach the probe connector to the front panel. Make sure the clamp ring is screwed down firmly. Turn the power switch on. For best performance, allow 30 minutes of warm-up before making measurements or calibrating the instrument.

III-2 CALIBRATION PROCEDURE

(a) General:

The calibration procedure should be performed before the instrument is used for current measurements. It should also be performed whenever probes are changed. Allow sufficient time for warm-up stability before calibrating.

(b) Calibration Against Internal CAL Signal:

Calibration against the internal CAL signal is a simple process which normally will provide the best possible accuracy. The accuracy and stability of the internal calibration signal is dependent upon precision high stability resistors and the initial factory calibration. Therefore, long-term accuracy and high stability is a characteristic of this method. After the instrument and probe have warmed up, depress the CAL button. Adjust the CAL screwdriver adjustment to obtain a 1000 digital meter reading. The instrument is now calibrated. Release the CAL button before zeroing the meter.

III-3 Probe and Instrument Zeroing:

(a) After calibration, the probe and instrument should be zeroed. Allow the probe to be closed with no current flow through the aperture. This is best achieved by having the probe aperture free of any conductors. Adjust the COARSE then FINE zero controls on the front panel of the 1776 to achieve a zero meter indication. The instrument is now prepared to make measurements.

SECTION IV

OPERATING INSTRUCTIONS

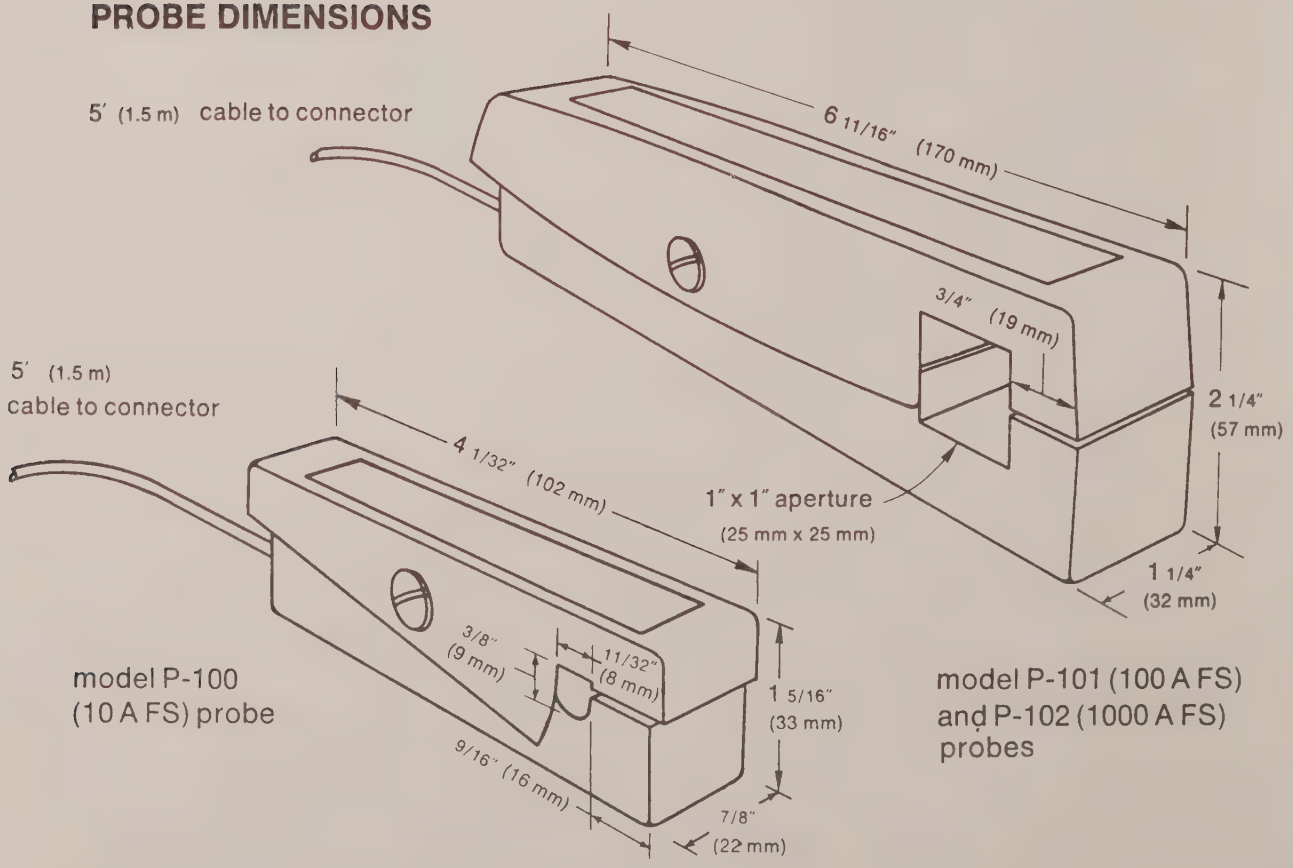
IV-1 Probes

(a) General:

There are three basic probes for the model 1776 Digital Current Meter. These are clamp-on hand-held probes designed to be opened and clamped around the conductor with one hand. For accurate readings, the probe must close completely around the conductor. The instrument range is set by the model of probe selected. See the chart below.

model	range, A
P-100	10.00
P-101	100.0
P-102	1000.0

PROBE DIMENSIONS


5' (1.5 m) cable to connector
6 11/16" (170 mm)
3/4" (19 mm)
2 1/4" (57 mm)
1" x 1" aperture (25 mm x 25 mm)
1 1/4" (32 mm)
5' (1.5 m) cable to connector
4 1/32" (102 mm)
3/8" (9 mm)
11/32" (8 mm)
1 5/16" (33 mm)
9/16" (16 mm)
7/8" (22 mm)
model P-100 (10 A FS) probe
model P-101 (100 A FS) and P-102 (1000 A FS) probes

(b) P-100 (10A) and P-101 (100A) Probes

The 10 and 100 ampere probes are ruggedly designed to clamp around conductors to provide a current measurement. The probes are sturdy and will withstand heavy use. The 10 and 100 ampere probes are conservatively rated so they may be used for a two times overrange with a slight reduction in accuracy. The reduction is an additional 1.5% of full scale accuracy. This means that a reading with a 10 ampere probe of 10 amperes has an uncertainty of 1% of full scale which would be .1 ampere. If the probe is used to make a reading at 19.99 amperes, the uncertainty is 2.5% of full scale (full scale equals 10 amperes). This is a total of .25 amperes.

(c) P-102 (1000A) Probe

The 1000 ampere probe has been designed to be hand-held and easily used. As a result of weight saving, the probe does not have a two times overranging capability that the lower current probes possess. Considerable error may be experienced if the probe is used above 1000 amperes. The 1000 ampere probe is also very durable and will stand heavy use.

SECTION IV-2

MEASUREMENT PROCEDURE

(a) General

The model 1776 is ready for operation at the conclusion of the pre-operational adjustments.

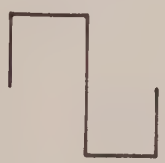
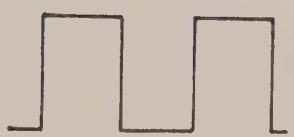
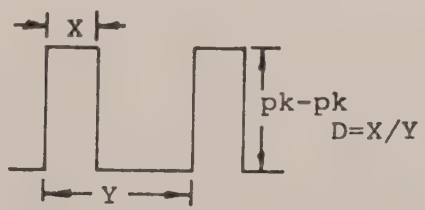
(b) dc Measurements

The ac/dc function switch should be in the dc position. Clamp the probe around the conductor of the unknown current. The current magnitude will appear on the digital panel meter. In addition, a voltage proportional to the current is available at the front panel output terminals. If the current is out of the range of the probe in use (see overrange section), disconnect the probe and connect the appropriate probe for the measurement. Changing probes requires a calibration and zeroing procedure before measurements can be made.

(c) ac Current Measurement

Depress the ac/dc function switch. Clamp the probe around the current carrying conductor. The unknown current value will be displayed on the digital readout. This value represents the rms value of the sinusoidal wave shape from 10 Hz to 5kHz. If the measured current is out of the range of the probe in use, change the probe and repeat the pre-operational adjustments. If the measured wave form is not a sinusoid, use the following chart to make the measurements. Multiply the meter reading by the appropriate form factor number. The 1776 is average responding, calibrated to indicate the rms value of a pure sine wave function.

ac conversion factors

waveform		factor (multiply by meter reading)	
SINE		pk-pk 0-pk rms avg	2.828 1.414 1.000 0.900
RECTIFIED SINE (FULL WAVE)		pk-pk 0-pk rms avg	1.414 1.414 1.000 0.900
RECTIFIED SINE (HALF WAVE)		pk-pk 0-pk rms avg	2.828 2.828 1.414 0.900
SQUARE		pk-pk 0-pk rms avg	1.800 0.900 0.900 0.900
RECTIFIED SQUARE		pk-pk 0-pk rms avg	1.800 1.800 1.272 0.900
RECTANGULAR PULSE		pk-pk 0-pk rms avg	0.9/D 0.9/D 0.9/D ½ 0.9D
TRIANGLE AND SAWTOOTH		pk-pk 0-pk rms avg	3.600 1.800 1.038 0.900

(d) Peak Read and Hold Measurements

Clamp the probe around the current-carrying conductor. Depress the peak reading function switch. The front panel digital meter will immediately register and hold the highest positive current present from the time the measurement was initiated to the present instant in time. Any subsequent higher peak will cause the reading to increase and hold at the new level. To prepare the instrument for a new peak reading, press the RESET button.

(e) Voltage Output

The jacks on the instrument front panel provide a voltage output proportional to the measured current. This can be used for observing the measured current wave form on an oscilloscope or for any other measurement purpose. On dc scale, the voltage output is a ± 1 volt analog for a full scale indication. On the ac scale, the output is 1 volt rms for a full scale indication.

(f) Battery Operation

The 1776 is capable of continuous battery operation up to eight hours. When the battery voltage drops below an acceptable level, a warning light will appear at the left side of the meter display. Battery operation at this point is not suggested, as the instrument accuracy may be reduced. Accurate operation may immediately be obtained by connecting the 1776 to the ac line.

The batteries are being charged any time the instrument is on the ac line. If the current meter is in use, the batteries are being trickle-charged to maintain a full charge. When the instrument is in the "off" mode, the batteries are in a maximum charging condition. Two hours of full charging for every one hour of portable operation should maintain the batteries at a fully charged condition.

(g) Display Overrange

If the digital current meter is used at a current level greater than two times the probe current rating, except for the P-102, 1000 A probe, the digital display will indicate this as an overrange condition. The three least significant digits will blank leaving the decimal point, a digital "one" and a polarity sign. To obtain a reading at this new level, the probe will have to be exchanged for a probe of the proper rated value.

(h) Frequency and Current Level Limits

Clamping a probe for the 1776 digital current meter around a current conductor in which there is a signal which exceeds the ampere·frequency products stated below may be damaging to both the instrument and the probe. This can happen when the 1776 is in either the dc or ac mode of operation.

Safe Limits on the Use of the Probes: When the model P-101, 100 A probe is used with the 1776 in the dc mode, the ac component of the current being measured must not exceed an ampere(rms)·frequency product of 1100 A·kHz. When the instrument is in the ac mode, the P-101 probe cannot be used to measure an ac current which has an ampere(rms)·frequency product greater than 750 A·kHz.

With the 1776 in either the ac or dc mode of operation, the model P-102, 1000 A probe must not be used to measure any current which has an ampere(rms)·frequency product greater than 1200 A·kHz.

Current spikes or pulses should be converted to an ampere·frequency rating to determine whether or not they fall within these safe limits of operation.

The P-100, 10 A probe is not subject to the limitations defined above.

SAFE LIMITS

PROBE	ac MODE	dc MODE
P-102	1200A·kHz	1200A·kHz
P-101	750A·kHz	1100A·kHz

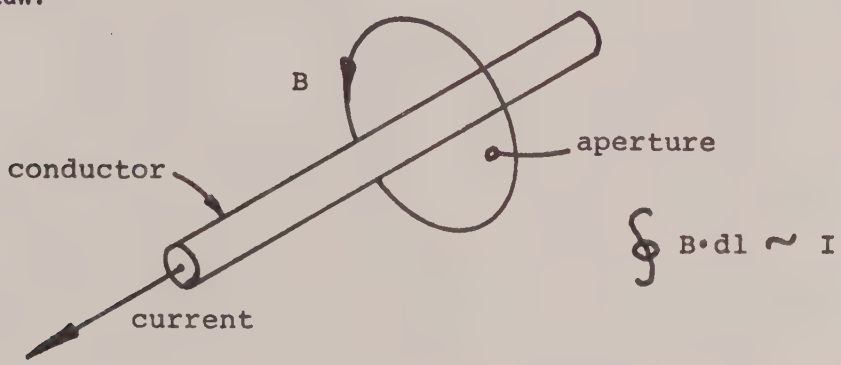
Potential High Voltage Damage: The magnetic fields associated with ac or transient currents generate a voltage in the 1776 probes. For waveshapes which exceed the specified safe limits this voltage becomes high enough to overload the protective devices in the instrument and do extensive damage to the circuitry.

Potential Thermal Damage: If the measured current is greater than the ampere·frequency limits, the temperature of the core in the probe could rise above the designed thermal limit. This increase in temperature will adversely affect the sensing element in the probe. Depending on the circumstances, the damage incurred by the probe may be permanent.

SECTION VI

Theory of Operation

A magnetic field is associated with every current flow. The strength of the magnetic field is related to the magnitude of the current. Ampere's Law states that the line integral of magnetic field (this is an integral around a closed path) is proportional to the net current flow through the line aperture. The Bell model 1776 digital current meter operates on the principle of Ampere's Law.



The model 1776 probe consists of a magnetic core and Hall generator. The core serves to concentrate the magnetic field surrounding the unknown current. In addition the core approximates the line integral of magnetic field. The Hall generator, in a gap in the core, senses this concentrated, integrated magnetic field and provides a voltage output which is proportional to the current flowing through the core aperture. This voltage is delivered to the circuitry of the 1776.

This signal is amplified and conditioned to provide the various features and outputs of the digital current meter. Conductors external

to the current probe normally will not effect the reading. The Hall generator is a high quality semi-conductor manufactured by F.W. Bell. Hall generators operate on the basis of the Hall Effect. This Effect occurs when a current flows through a conductor in the presence of a magnetic field. A voltage will be developed that is proportional to the current magnitude multiplied by the external field magnitude. In this way a voltage proportional to magnetic field is derived.

WARRANTY

F. W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof. This warranty covers instruments which, within one year after the shipping date to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F. W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F. W. BELL, INC., and F. W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F. W. BELL, INC. instruments.

DAMAGES IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

All shipments of F. W. BELL, INC. instruments should be made via United Parcel Service or air freight. Always use the original shipping carton and inserts, if possible, or pack the instrument in a sturdy container and surround the entire instrument with two or three inches of shock-absorbing material.

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MAINTENANCE FOR MODEL

1776 CURRENT METER

1. INTRODUCTION

This section contains the necessary instructions and diagrams for maintaining the model 1776 Digital Current Meter. In addition to the schematic diagram, a block diagram showing typical voltage levels is provided to aid in trouble shooting. Repair and adjustment of the instrument should be attempted in the field only where adequate test equipment and qualified personnel are available. Refer to the warranty page for the procedure to be followed should factory repair service be required. Caution: CMOS. Proper handling procedures must be used.

2. TEST EQUIPMENT

Voltmeter - Fluke 8000A or equivalent
Oscilloscope - Tektronix 503 or equivalent

3. COVER REMOVAL

Caution - Always disconnect the power cord from the power line when removing or replacing the cover. To remove the cover, remove the two screws on the rear and one screw from the front panel of the unit.

4. PERFORMANCE TEST

A. Preliminary

1. Make sure the power cord is properly connected and fully seated in the receptical.

2. Check the fuse for burn-out. Correct fuse size is 1/8 amp 3AG slow-blow for 110 Volt operation; 1/16 amp 3AG slow-blow for 220 Volt operation.

3. Check the battery connections on the PC board and at the batteries.

4. Check for damage to the probe, cable, connector contacts, cores, etc.

B. Calibration Check

1. Plug the probe securely into the front panel.

2. Push the CAL button in; the meter should read near 1000.

3. Using the CAL control, a meter reading of 1000 should be obtainable with approximately 20 counts on each side of 1000.

4. Voltage at the output jacks should be 1 Volt dc for a full scale (1000) meter reading ±2 counts.

C. Zero Test

1. Release the CAL button and return to the dc mode of operation. Adjust the zero controls to obtain a zero meter reading.

2. A total range of approximately -700 to +700 counts typical should be obtainable.

D. Peak Read Test

1. With the ac/dc switch out (instrument in the dc mode), use the zero controls to adjust a plus (+) 010 counts on the meter.

2. Push in the Peak hold button and reset the Peak Detector Circuit by temporarily depressing the Peak reset button. The meter should then read 010 counts ± one digit.

3. While holding the Peak reset button in, the meter should read 000 ± one count.

4. Release the Peak reset and hold buttons (return to the dc mode of operation) and use the zero controls to set plus (+) 700 counts on the meter.

5. Push in the Peak hold button and reset the Peak detector by temporarily depressing the Peak reset button. The meter should then read 700 ± one count.

5. ADJUSTMENT AND ALIGNMENT PROCEDURE

A. Digital Voltmeter (DVM) Adjustment

1. Disconnect probe from the 1776 Digital Current Meter.

2. Connect an external voltmeter to the output jacks on the front panel of the 1776.

3. Using the zero controls on the front panel of the 1776, obtain a zero reading on the external voltmeter.

4. Depress ac/dc switch. The digitial voltmeter display should read zero; if not adjust the ac null pot (R227) and then release ac/dc switch.

5. Temporarily connect pin P-114 to terminal P-20S of the meter board (bottom terminal) with a clip lead.

6. In the dc mode, adjust front panel zero controls R226 for a reading of 700 on the 1776's digital voltmeter display.

7. Depress ac/dc switch and adjust ac CAL control for a reading of 778 on the 1776's digital voltmeter display.

8. Remove the clip lead from pin P-114 and terminal P-20S of the meter board.

9. Re-zero the 1776's digital voltmeter display using the front panel controls.

10. Connect a probe to the 1776.

11. Depress the CAL button and use the CAL control to obtain a reading of 1000 volts on external voltmeter.

12. Adjust dc CAL control to obtain a reading of 1000 on the 1776's digital voltmeter display.

B. Peak and Hold Calibration

1. In the dc mode of operation, zero the 1776 instrument.

2. Depress the hold button.

3. While holding in the reset button, adjust R137 (internal zero adjustment) for a flashing plus sign (+) and a reading of 000 on the 1776's digital voltmeter display.

4. Release the reset and hold buttons. In the dc mode, use the zero controls to set a reading of +010 on the 1776's digital voltmeter display.

5. Depress the Peak hold button. Push in and release the Peak reset button and adjust R138 (low level Peak CAL) for a reading of +009.

6. Release the Peak hold button. In the dc mode, use the zero controls to set a positive (+) 700 on the 1776's display.

7. Depress the Peak hold button. Push and release the Peak reset button and adjust R136 (high level Peak CAL) for a reading of 700 $\pm$ one count.

8. Release the Peak hold button.

Note: Low and high CAL adjustment (steps 5 and 7) must be approached from a lower level than the desired setting.

C. Amplifier Adjustments

1. Disconnect the probe; disconnect the blue/black and green/black leads from terminals P-128 and P-125.

2. Connect terminals P-103 and P-104 to each other.

3. Connect a 100 ohm ±20% resistor across pins P-101 and P-107.

4. Connect a 100 ohm ±20% resistor across pins P-101 and P-102.

5. Connect the ground lead of an external voltmeter to Pin P-101 and the input to pin P-118.

6. Using a clip lead, connect the two shorted terminals P-103 and P-104 to pin P-101. Adjust R106 (offset null) for a reading of 0.000 Volt ±0.5 millivolt on the external voltmeter.

7. Remove the lead connected to pin P-101 in step 6 and connect it to pin P-102. Adjust R105 (Common Mode Rejection) for a reading of 0.000 Volts ±1 millivolt on the external voltmeter.

8. Remove the two 100 ohm resistors, clip lead, and short. Reconnect the blue/black lead to pin P-128 and the green/black lead to pin P-125 and check the operation of the 1776's zero controls.

1776 PARTS LIST

Abbreviations

Cer	Ceramic	MYL	Mylar
Comp	Composition	OP AMP	Operational Amplifi
DVM	Digital Volt Meter	Ω	ohm
Elect or ELE	Electrolytic	p	Pico or 10^{-12}
F	Farad	Reg	Voltage Regulator
FET	Field Effect Transistor	Seg	Segment
FOP	Factory selected for optimum performances	T	Tantalum
		TG	Transmission Gate
IC	Integrated Circuit	μ	Micro or 10^{-6}
k	Kilo or 10^3	V	Working Volts
LED	Light Emitting Diode	Var	Variable
M	Meg or 10^6	W	Watt
MF	Metal Film	WW	Wire Wound
Mini DIP	8 pin, dual in-line package		

BASE PRINTED CIRCUIT BOARD

Schematic Ref	Value	Specifications	F. W. Bell Part No.
R100	6.8 k Ω	5% 1/2 W Comp	13200
R101	10 k Ω	1% 1/4 W MF	16350
R102	10 k Ω	1% 1/4 W MF	16350
R103	30.1 k Ω	1% 1/4 W MF	16350
R104	29.4 k Ω	1% 1/4 W MF	16529
R105	1 k Ω	Cer Var	22044
R106	20 k Ω	Cer Var	22047
R107	200 Ω	1% 1/4 W MF	15840
R108	4.7 M Ω	5% 1/4 W Comp	12440
R109	49.9 k Ω	1% 1/4 W MF	16579
R110	4.87 k Ω	0.1% 1/4 W MF	15311
R111	4.32 Ω	0.1% 1/10W WW	18375
R113	121Ω-127Ω, FOP	1% 1/4 W MF	15430
R114	20 Ω	0.1% 1/2 W Comp	12600
R115	5.11 k Ω	0.1% 1.4 W MF	15315
R116	10 k Ω	5% 1/2 W Comp	13240
R118	10 k Ω	5% 1/2 W Comp	13240
R119	10 k Ω	5% 1/2 W Comp	13240
R120	10 k Ω	5% 1/2 W Comp	13240
R121	1 M Ω	5% 1/2 W Comp	13650
R122	1 k Ω	5% 1/2 W Comp	13000
R123	4.99 k Ω	1% 1/4 W MF	16240
R124	10 k Ω	1% 1/4 W MF	16350
R125	20 Ω	5% 1/2 W Comp	12600
R126	20 Ω	5% 1/2 W Comp	12600
R127	1.5 k Ω	5% 1/2 W Comp	13040
R128	1 M Ω	5% 1/2 W Comp	13650
R129	2 k Ω	5% 1/2 W Comp	13070
R130	1 k Ω	5% 1/2 W Comp	13000
R131	1 k Ω	5% 1/2 W Comp	13000
R132	2 k Ω	5% 1/2 W Comp	13070
R133	10 k Ω	1% 1/4 W MF	16350
R134	5.11 k Ω	1% 1/4 W MF	16230
R135	4.46 k Ω	1% 1/4 W MF	16230
R136	1 k Ω	Cer Var	22044
R137	20 k Ω	Cer Var	22047
R138	2 k Ω	Cer Var	22045
R139	2.37 k	1% 1/4 W MF	16171
R140	200 Ω	1% 1/4 W MF	15840
R141	10 k Ω	5% 1/2 W Comp	13240
R142	100 k Ω	1% 1/4 W MF	13490
R143	24.9 k Ω	1% 1/4 W MF	16515
R144	24.9 k Ω	1% 1/4 W MF	16515

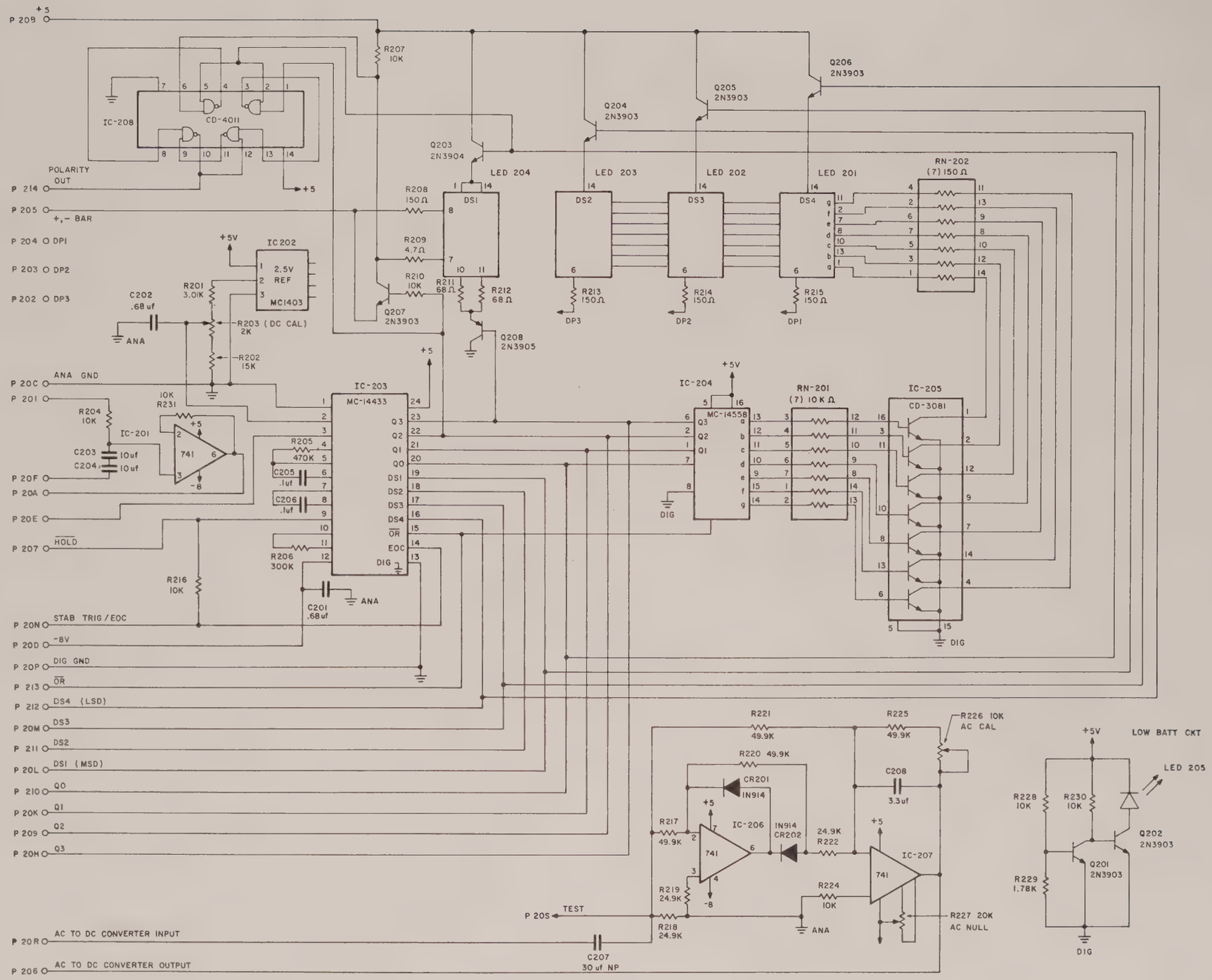
Schematic Ref	Value	Specifications	F. W. Bell Part N
R145	100 k Ω	1% 1/4 W MF	16620
R146	130 k Ω	5% 1/2 W Comp	13510
R147	270 k Ω	5% 1/2 W Comp	13580
R148	10 k Ω	1% 1/4 W MF	16350
R149	10 k Ω	5% 1/2 W Comp	13240
R150	124 k Ω	1% 1/8 W MF	15128
R151	124 k Ω	1% 1/8 W MF	15128
R152	124 k Ω	1% 1/8 W MF	15128
R153	124 k Ω	1% 1/8 W MF	15128
R154	124 k Ω	1% 1/8 W MF	15128
R155	124 k Ω	1% 1/8 W MF	15128
R156	124 k Ω	1% 1/8 W MF	15128
R157	124 k Ω	1% 1/8 W MF	15128
R158	124 k Ω	1% 1/8 W MF	15128
R159	124 k Ω	1% 1/8 W MF	15128
R160	124 k Ω	1% 1/8 W MF	15128
R161	124 k Ω	1% 1/8 W MF	15128
R162	124 k Ω	1% 1/8 W MF	15128
R163	61.9 k Ω	1% 1/8 W MF	15140
R164	61.9 k Ω	1% 1/8 W MF	15140
R165	61.9 k Ω	1% 1/8 W MF	15140
R166	61.9 k Ω	1% 1/8 W MF	15140
R167	61.9 k Ω	1% 1/8 W MF	15140
R168	61.9 k Ω	1% 1/8 W MF	15140
R169	61.9 k Ω	1% 1/8 W MF	15140
R170	61.9 k Ω	1% 1/8 W MF	15140
R171	61.9 k Ω	1% 1/8 W MF	15140
R172	61.9 k Ω	1% 1/8 W MF	15140
R173	61.9 k Ω	1% 1/8 W MF	15140
R174	8.2 Ω	5% 2 W WW	19930
R175	7.5 Ω	5% 2 W WW	19920
R176	3.3 Ω	5% 2 W WW	19845
R177	620 Ω	5% 1/2 W Comp	12950
R178	100 Ω	5% 1/2 W Comp	12770
R179	100 k Ω	5% 1/2 W Comp	13490
R180	100 k Ω	5% 1/2 W Comp	13490
R181	100 k Ω	5% 1/2 W Comp	13490
R182	10 k Ω	5% 1/2 W Comp	13240
R183	10 k Ω	5% 1/2 W Comp	13240
R184	10 k Ω	5% 1/2 W Comp	13240
R185	100 k Ω	5% 1/2 W Comp	13490
R186	100 k Ω	5% 1/2 W Comp	13490
R187	100 k Ω	5% 1/2 W Comp	13490
R188	10 k Ω	5% 1/2 W Comp	13240
R189	10 k Ω	5% 1/2 W Comp	13240
R190	10 k Ω	5% 1/2 W Comp	13240
R191	1 k Ω	5% 1/2 W Comp	13000
R192	100 k Ω	5% 1/2 W Comp	13490
R193	100 k Ω	5% 1/2 W Comp	13490
R194	100 k Ω	5% 1/2 W Comp	13490
R195		5% 1/2 W Comp	

Schematic Ref	Value	Specifications	F. W. Bell Part No
R196	680 Ω	5% 1/2 W Comp	12960
R197	47 k Ω	5% 1/2 W Comp	13400
R198	24 k Ω	5% 1/2 W Comp	13330
R199	47 k Ω	5% 1/2 W Comp	13400
R101 A	3.3 Ω	5% 2 W WW	19845
R102 A	10 Ω	5% 1/2 W Comp	12570
R103 A	10 Ω	5% 1/2 W Comp	12570
R104 A	22 MΩ	5% 1/2 W Comp	13670
R105 A	470 k Ω	5% 1/2 W Comp	13610
R106 A	10 MΩ	5% 1/2 W Comp	13680
R107 A	240 Ω	5% 1/2 W Comp	12850
R1	20 k Ω	10 turn Vari	21680
R2	250 k Ω	Vari	21245
R3	5Ω	Vari	
C101	2.2 µf @ 35 V	Tan	25680
C102	0.1 µf @ 20 V	Cer	25230
C103	0.0047 µf @ 200 V	Myl	24450
C104	180 pf @ 1000 V	Cer	25400
C105	0.1 µf @ 20 V	Cer	25230
C106	0.1 µf @ 20 V	Cer	25230
C107	0.1 µf @ 20 V	Cer	25230
C108	0.0033 µf @ 200 V	Myl	24430
C109	1 µf @ 35 V	Tan	25670
C110	0.001 µf @ 1000 V	Cer	25510
C111	56 pf @ 1000 V	Cer	25330
C112	330 pf @ 1000 V	Cer	25479
C113	10 µf @ 6 V	Elect	23310
C114	10 µf @ 6 V	Elect	23310
C115	4700 µf @ 10 V	Elect	23030
C116	350 µf @ 16 V	Elect	23380
C117	350 µf @ 16 V	Elect	23380
C118	350 µf @ 16 V	Elect	23380
C119	5 µf (2-10 µf Caps) NP	Elect	23310
C120	1 µf @ 35 V	Tan	25670
C121	.01 µf		25520
C122	.01 µf @ 200 V	Myl	25520
C123	56 pf @ 1000 V	Cer	25330
C124	10 pf @ 1000 V	Cer	25250
C125	.001 @ 1000 V	Cer	25510
C126	10 pf @ 1000 V	Cer	25250
C127	10 pf @ 1000 V	Cer	25250
C128	.001 µf @ 1000 V	Cer	25510
C129	100 pf @ 1000 V	Cer	25380
C130	0.1 µf @ 20 V	Cer	25230
CR101	IN914	Diode	28015
CR102	IN456	Diode	28000
CR103	IN5231A (5.1 V)	Zener	28450
CR104	IN5231A (5.1 V)	Zener	28450
CR105	IN4003	Diode	28090
CR106	IN4003	Diode	28090
CR107	IN4003	Diode	28090
CR108	IN4003	Diode	28090
CR109	IN4003	Diode	28090
CR110	IN4003	Diode	28090

Schematic Ref	Value	Specifications	F.W. Bell Part No.
CR111	IN914	Diode	28015
CR112	IN914	Diode	28015
CR113	IN914	Diode	28015
CR114	IN914	Diode	28015
CR115	IN914	Diode	28015
CR116	IN914	Diode	28015
CR117	IN5343B (7.5 V)	Zener	28481
CR118	IN5343B (7.5 V)	Zener	28481
CR120	IN5231A (5.1 V)	Zener	28450
Q101	2N3903	Transistor	29030
Q102	2N3903	Transistor	29030
Q103	2N3903	Transistor	29030
Q104	TI573	FET	29290
Q105	2N5190	Transistor	29190
Q106	2N5190	Transistor	29190
Q107	2N3905	Transistor	29040
Q108	2N3903	Transistor	29030
Q109	2N3905	Transistor	29040
Q110	2N3903	Transistor	29030
Q111	2N3905	Transistor	29040
Q112	2N3903	Transistor	29030
Q113	2N5190	Transistor	29190
Q114	2N5193	Transistor	29200
IC101	741	Op Amp	29985
IC102	741	Op Amp	29985
IC103	741	Op Amp	29985
IC104	7805	Reg	29984
IC105	4001 (CMOS)	Quad Nor	30074
IC106	709	Op Amp	29950
IC107	CA 3130	Op Amp	30076
IC108	311	Comparator	29983
IC109	741	Op Amp	29985
IC110	4040 (CMOS)	12 Stage Ripple Counter	30073
IC111	4011	Quad Nand	30072
IC112	78M08	Reg	29986
IC113	79M08	Reg	29987
IC114	4001 (CMOS)	Quad Nor	30074
IC115	4016 (CMOS)	Quad T G	30075
IC116	741	Op Amp	29985
IC117	741	Op Amp	29985
IC118	4001	Quad Nor	30074
L101	Coil/Core	Inductor	26185/44379
T101	LA-1994	Transformer	26035
T102	LB-1993/Core	Transformer	26187/4457
I101	#63	Lamp	30481
S101	6 Pole 5 Station	Switch	34399
F101	1/8 A-110 V (SB)	Fuse	30700
	1/16A-220 V (SB)	Fuse	30680
B1	5 volt	Battery Pkg.	35630
J1		Amp Connector	31723
	For use in J1 (9) Pins		31351

Schematic Ref	Value	Specifications	F. W. Bell Part No.
R201	3.01 kΩ	1% 1/8W MF	15150
R202	5.0 kΩ	1% 1/8W MF	15160
R203	2 kΩ	CER VAR	22045
R204	10 kΩ	5% 1/4W Comp	12280
R205	470 kΩ	5% 1/4W Comp	12339
R206	300 kΩ	5% 1/4W Comp	12335
R207	10 kΩ	5% 1/4W Comp	12280
R208	150 Ω	5% 1/4W Comp	12087
R209	4.7 Ω	5% 1/4W Comp	12080
R210	10 kΩ	5% 1/4W Comp	12280
R211	68 Ω	5% 1/4W Comp	12085
R212	68 Ω	5% 1/4W Comp	12085
R213	150 Ω	5% 1/4W Comp	12087
R214	150 Ω	5% 1/4W Comp	12087
R215	150 Ω	5% 1/4W Comp	12087
R216	10 kΩ	5% 1/4W Comp	12280
R217	49.9 kΩ	1% 1/8W MF	15127
R218	24.9 kΩ	1% 1/8W MF	15126
R219	24.9 kΩ	1% 1/8W MF	15126
R220	49.9 kΩ	1% 1/8W MF	15127
R221	49.9 kΩ	1% 1/8W MF	15127
R222	24.9 kΩ	1% 1/8W MF	15126
R22			
R224	10 kΩ	1% 1/8W MF	15121
R225	49.9 kΩ	1% 1/8W MF	15127
R226	10 kΩ	CER VAR	22085
R227	20 kΩ	CER VAR	22047
R228	10 kΩ	1% 1/8W MF	15121
R229	1.78 kΩ	1% 1/8W MF	15091
R230	10 kΩ	5% 1/4W Comp	12280
R231	10 kΩ	5% 1/8W Comp	12280
RN201	10 kΩ	7-Resistor Network	22705
RN202	150 Ω	7-Resistor Network	22660
C201	.68 µf	TAN	25690
C202	.68 µf	TAN	25690

Schematic Ref	Value	Specifications	F. W. Bell Part No.
C203	10 µf @ 16 V	Elect	23310
C204	10 µf @ 16 V	Elect	23310
C205	.1 µf @ 400	Myl	25171
C206	.1 µf @ 400	Myl	25171
C207	33 µf @ 16 V	NP Elect	23390
C208	3.3 µf	Elect	23035
CR201	1N914	Diode	28015
CR202	1N914	Diode	28015
Q201	2N3903	Transistor	29030
Q202	2N3903	Transistor	29030
Q203	2N3904	Transistor	29035
Q204	2N3903	Transistor	29030
Q205	2N3903	Transistor	29030
Q206	2N3903	Transistor	29030
Q207	2N3903	Transistor	29030
Q208	2N3905	Transistor	29040
IC-201	741	OP AMP	29985
IC-202	MC-1403	2.5 V REF	29989
IC-203	MC-14433	A/D	30077
IC-204	MC-14558	7 Seg. Decode/Driver	30070
IC-205	CD-3081	Transistor Array	29981
IC-206	741	OP AMP	29985
IC-207	741	OP AMP	29985
IC-208	CD-4011	Quad Nand Gate	30072
LED-201	hp5082-7650	7 Seg. LED	30520
LED-202	hp5082-7650	7 Seg. LED	30520
LED-203	hp5082-7650	7 Seg. LED	30520
LED-204	hp5082-7652	+1 overflow	30530
LED-205		LED	30530



FOR 2.000 V FS

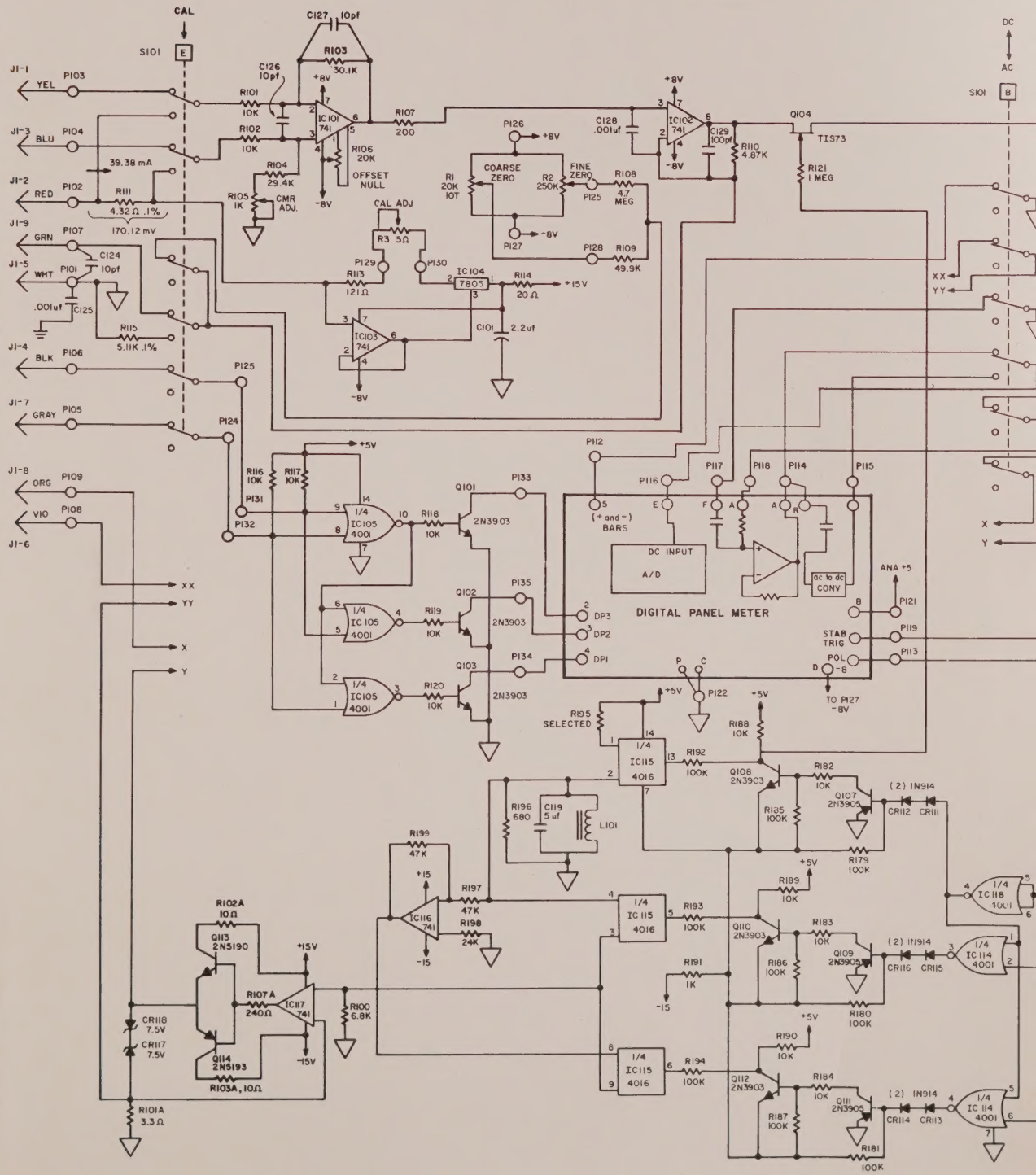
R201 = 3.01K
R202 = 15.0K
R205 = 470KΩ

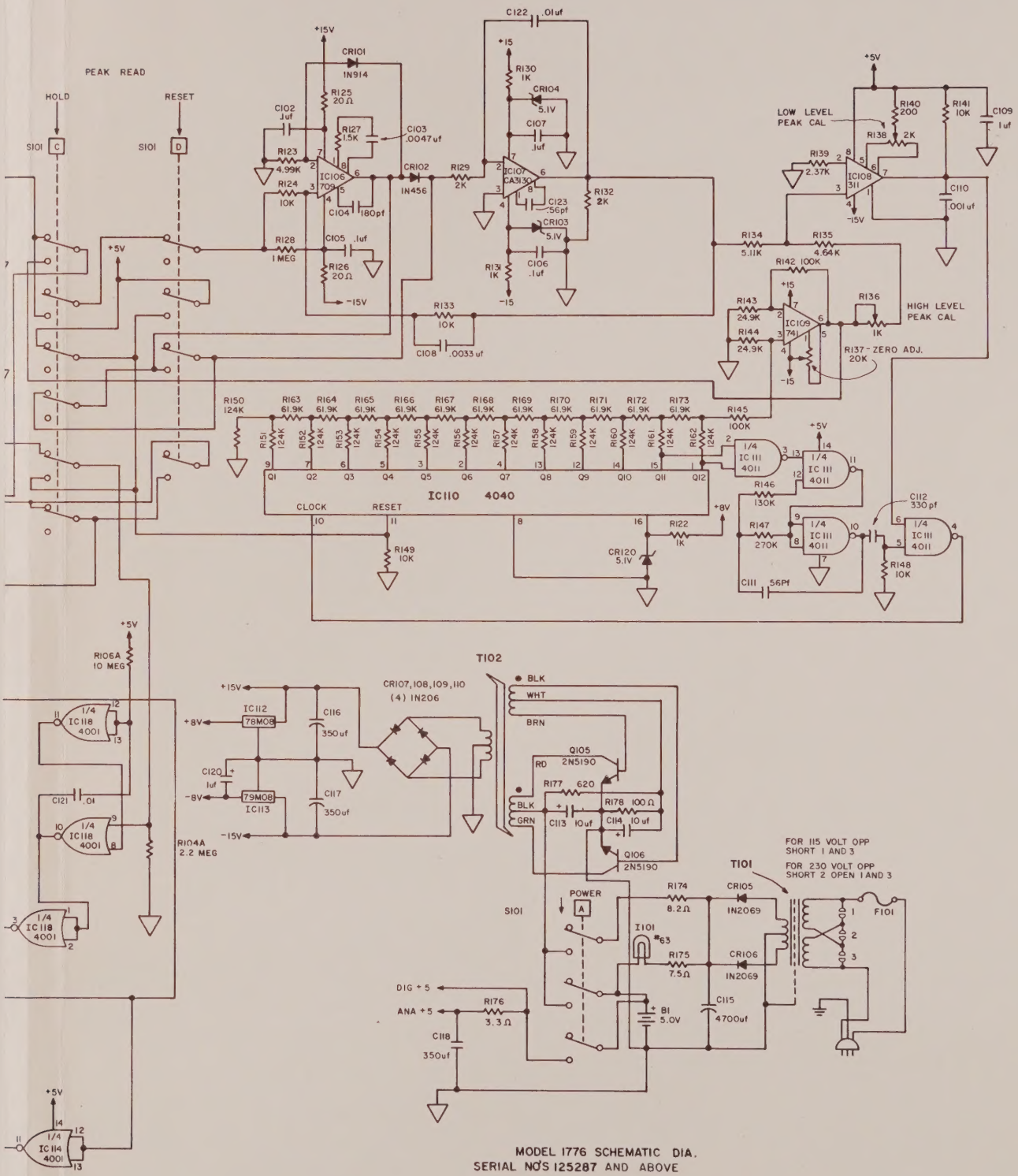
FOR 200 mv FS

R201 = 17.4 KΩ
R202 = 0 Ω
R205 = 47 KΩ

$3\frac{1}{2}$ DIG. PANEL METER

UD-3316


CAL
S101
E
C127 10pf
R103 30.1K
C126 10pf
+8V
J1-1
YEL
P103
R101 10K
IC 101 741
R107 200
J1-3
BLU
P104
R102 10K
R106 20K
OFFSET NULL
39.38 mA
J1-2
RED
P102
R111 4.32Ω .1%
170.12 mV
R104 29.4K
R105 1K
CMR ADJ.
-8V
J1-9
GRN
P107
C124 10pf
J1-5
WHT
P101
.001uf
C125
R115 5.11K .1%
J1-4
BLK
P106
J1-7
GRAY
P105
P125
P124
CAL ADJ
R3 5Ω
P129
P130
R113 121Ω
IC 104 7805
R114 20Ω
+15V
IC103 741
C101 2.2uf
P126
+8V
COARSE ZERO
R1 20K 10T
R2 250K
FINE ZERO
P125
R108 47 MEG
P127
-8V
P128
R109 49.9K
C128 .001uf
IC102 741
C129 100pf
R110 4.87K
Q104
TIS73
R121 1 MEG
DC
AC
S101
B
XX
YY
X
Y
J1-8
ORG
P109
VIO
P108
J1-6
R116 10K
R117 10K
+5V
P131
P132
1/4 IC105 4001
Q101
P133
R118 10K
2N3903
Q102
P135
R119 10K
Q103
P134
R120 10K
P112
P116
P117
P118
P114
P115
5 (+ and -) BARS
E
F
A
A
R
DC INPUT A/D
dc to dc CONV
DIGITAL PANEL METER
DP3
DP2
DP1
ANA +5
P121
STAB TRIG
P119
POL
P113
D
-8
TO P127 -8V
P
C
P122
R195 SELECTED
R188 10K
IC115 4016
R192 100K
Q108 2N3903
R182 10K
Q107 2N3905
(2) IN914
CR112
CR111
R185 100K
R179 100K
R196 680
C119 5 uf
L101
R199 47K
+15
IC116 741
R197 47K
R198 24K
-15
R189 10K
R193 100K
Q110 2N3903
R183 10K
Q109 2N3905
(2) IN914
CR116
CR115
R186 100K
R180 100K
R191 1K
R190 10K
R194 100K
Q112 2N3903
R184 10K
Q111 2N3905
(2) IN914
CR114
CR113
R187 100K
R181 100K
IC 118 4001
IC 114 4001
R102A 10Ω
Q113 2N5190
R107A 240Ω
IC117 741
R100 6.8K
CR118 7.5V
CR117 7.5V
Q114 2N5193
R103A, 10Ω
R101A 3.3Ω



MODEL 1776 SCHEMATIC DIA.
SERIAL NO'S 125287 AND ABOVE

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